

AUGMENTED REALITY

The Ethical Importance of a Shared Context



Thesis

Master Applied Ethics

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Preface

NEO

The Matrix. What is the Matrix?

TRINITY

Twelve years ago I met a man, a great man, who said that no one could be told the answer to that question. That they had to see it, to believe it. He told me that no one should look for the answer unless they have to because once you see it, everything changes. Your life and the world you live in will never be the same. It's as if you wake up one morning and the sky is falling. The truth is out there, Neo. It's looking for you and it will find you, if you want it to.

Twelve years ago I saw a movie, a great movie that opened my eyes. The Matrix^{1,2} not only showed that everything is possible, but also that everything could be an illusion, that we could be living in a virtual reality without knowing it. Just when I had to consider topics for this thesis, the movie once again caught my attention. I might not be the biggest computer-geek or game-nerd, I do admire the possibilities computers and virtual realities offer. But the Matrix also reminded me of the potential dangers. As homage to virtual reality, and to the Matrix, I started exploring the world of virtual reality for an ethically interesting debate. My attention was caught by the term augmented reality. In augmented reality I saw not only the endless possibilities, the enrichment of life with the technology, but also the potential danger of it taking over our daily lives. Augmented reality is just one step closer to the matrix becoming reality. Some chapters open with a quote from the movie, just to illustrate this latter point. I will not try to lure you into an apocalyptic world caused by augmented reality, but hope these quotes will once again open your eyes as the movie did to me. And if you have not seen the movie so far: go see it!

¹ Wachowsky, Andy; Wachowsky, Lana. *The Matrix*. United States: Warner Bros. pictures/Village Roadshow pictures, 2009

² For those of you who are unfamiliar with the movie, here is a little synopsis: "*Thomas A. Anderson is a man living two lives. By day he is an average computer programmer and by night a malevolent hacker known as Neo. Neo has always questioned his reality but the truth is far beyond his imagination. Neo finds himself targeted by the police when he is contacted by Morpheus, a legendary computer hacker branded a terrorist by the government. Morpheus awakens Neo to the real world, a ravaged wasteland where most of humanity has been captured by a race of machines which live off of their body heat and imprison their minds within an artificial reality known as the Matrix. As a rebel against the machines, Neo must return to the Matrix and confront the agents, super powerful computer programs devoted to snuffing out Neo and the entire human rebellion.*" (Found on: The Internet Movie Data Base, <http://www.imdb.com/title/tt0133093/plotsummary>, 14th of June, 2011)

Besides the Matrix and my love for virtual reality, I would like dedicate this thesis to all those who have helped me along the way: my parents, family and friends for their undying support and for providing me with the incentive to keep on studying; the teachers, and my fellow students for the endless discussions and comments on this thesis; to Yolande Kolstee (AR Lab, Royal Academy of Art (KABK)), Christian van 't Hof and Riny van Est (Rathenau Institute) for their professional opinions; and my supervisor Frans Brom for guiding me towards this end-result. I hope you will enjoy it, I know I did!

Abstract

In this thesis I will discuss the ethical impact augmented reality can have on our moral deliberation. Augmented reality places a layer of virtual objects onto our perception of reality. I will show that augmented reality has the potential to alter our perception of reality, which is an important aspect in determining the rightness of our actions. The context of a moral act provides us with reasons why we should prefer one act over another. Other people, who are affected by our moral behaviour, provide one of the strongest reasons to prefer a certain act. These second-personal reasons will lose strength without a shared understanding of reality. You would be unable to understand the reasons they are providing. Furthermore, the merging of the virtual world with the real world causes a moral vertigo: confusion about what is right in a certain context. Through altering our perception of reality augmented reality changes the context. But it could misrepresent, or even mis-present reality. The augmented reality could be false, leading to biased believes about the real world. Furthermore, altering the context alters the reasons to act morally. It could confuse people even further about what is right. And augmented reality makes our virtual behaviour real. While we used to steer virtual characters through a virtual world, with augmented reality we steer ourselves through the augmented world. Virtual misbehaviour suddenly becomes real.

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Introduction

We love to dream about a better world. A world without war, without hunger, or a world in which we are rich and famous. Dreaming provides us with hope of a better future, and sparks our creativity. It helps us to create ideas, ideas for movies, books, music, or inventions. In return, ideas can inspire our dreams. You can simply drift away in a good book, or a good movie. The more we feel like we are actually part of the story, the better we think the book, or movie, has been. The ability to immerse ourselves into a vivid dream-world seems to be an important aspect of the success of movies. It sure does explain the success of current 3D-movies. Or think about the success of video-games. In a virtual world we are actually part of the story, determining the outcome ourselves (at least to some extent). In the game *Second-Life*, one could actually live another, virtual, life. This virtual 'you' did in large parts the same things as a real person would do: buying clothes, designing an own house, meeting people in bars, clubs, playing games. With one difference, the virtual 'you' could become the 'you' you always wanted to be: sexy and popular.

'The Matrix' not only showed how problematic it could be when computers take over the world. More importantly, it showed me the danger of total immersion into a virtual world. When the virtual world becomes so real, that it is no longer any different from the real world, we would literally be lost in a virtual world. For some people, playing games in virtual worlds already became a replacement for the real world. The time they spent on playing video-games was so out of proportion, they hardly did anything else besides sleeping and gaming. In a way, you could argue that they have become addicted to the real world³.

Towards Augmented Reality

In 'The Matrix' a computer took hold over the human senses by tapping directly into our nervous system. It could control what we saw, felt, heard and smelt. Only then it could replace the real world with a virtual world. But in our current reality the virtual world can only exist alongside the real world. Although we might get lost in a video-game, we still have to take a break at some point. We still need to eat, sleep, and go to the bathroom every once in a while. And it still takes place in front of your eyes; you are not really part of it. You merely play with a virtual character in a virtual world. But not for long. Recent developments, mainly in the gaming industry, are focussing on letting the user become part of the virtual world. Nintendo's WII allowed the user to actively control the virtual character. No longer did you use a joystick to control the character, but the character

³ A Dutch documentary-TV-programme, called Zembla, aired a special on gaming-addiction, which is available to view online. It features interviews with some gaming-addicts and their relatives, and neatly shows the consequences of their addiction. (Zembla. *Gameverslaafd*. VARA/NPS, aired 27th of January, 2008)

would mimic your moves using a motion-sensor controller. And last year Microsoft released the Kinect-controller for the Xbox 360 gaming console. This controller is basically a camera which is able to track human movement. Through identifying key markers of the human body (hands, elbows, shoulders, etc.) the Kinect translates the movements of your body to the in-game character. The Kinect could be seen as a device that allowed the real world, you, to influence events occurring in the real world. Your movements are triggering virtual movements.

The Kinect could be seen as a form of '*augmented virtuality*'. This thesis however is on '*augmented reality*'. The difference is that in augmented reality the real world is not influencing the virtual world, but virtual objects are interacting in the real world. By placing some sort of virtual layer over the real world, it provides virtual feedback to real-life events. Although the technology itself dates back to at least the early nineties⁴, it is emerging rapidly over the recent years. An important development is the success of smart-phones, which have the necessary components for augmented reality to work. Most commercial applications of augmented reality therefore are found among the applications for smartphones. These applications provide a virtual layer of information based on the real world surrounding the phone. But less commercial applications feature head-mounted devices (HMD's), which place a virtual layer right in front of your eyes. The augmented world is no longer limited to the screen of your mobile, but completely surrounds you.

Aim of Thesis

Virtual reality creates an alternate reality. Augmented reality alters reality. The main difference is that virtual reality has to exist alongside reality. This limits the feeling of immersion into a dream-world. As said, we occasionally have to step out of the virtual world, for example to visit the toilet. Augmented reality enables us to attach the virtual world to the real world. You could go to the toilet and still be in a (semi-)virtual surrounding. Your toilet suddenly can be on top of a (virtual) mountain, or in a (virtual) desert. You could just 'photoshop' whatever you see in whatever you want to see. Living in a dream-world suddenly becomes quite real to achieve. Is augmented reality a dream come true?

So far I can judge, augmented reality certainly offers seemingly limitless opportunities. However, I do wish to raise some concerns. The altering of reality can have important ethical implications, which I hope to address in this thesis. First we need

⁴ It is believed that the term '*augmented reality*' was coined by Thomas Caudell & David Mizell in 1992. Working for Boeing at that time, they were investigating ways to enhance aircraft manufacturing. Manufacturing workers needed large quantities of information in order to perform their jobs, scattered over a large working area. To make their lives easier, Caudell & Mizell proposed to show the information straight in the worker's eyesight, through head-mounted displays (HMD). (Villagomez, Gianpierre. Augmented Reality. [Lecture notes] *EECS 741: Computer Vision*, University of Kansas, 2010)

to know what augmented reality really is. In the first chapter I will try to relate augmented reality not only to virtual reality, but to reality as well. In the second chapter I will briefly discuss the possibilities augmented reality has, addressing both existing and potential applications. I will furthermore sketch our augmented future: where is the technology heading to? As said, this future might seem bright, but there are some ethical concerns. To understand these concerns we have to take a closer look at moral acting. I will argue that the context of a moral act provides us with reasons to prefer a morally right act over a moral wrong act. I will furthermore argue that there appears to be a relational aspect to the context. A moral act consists in another person that can be affected by our acting. This other person can make certain claims, based on her dignity, of the moral agent. These claims provide the agent with second-personal reasons to act in a certain way. Although these reasons are not decisive in moral deliberations, they do have more normative strength than other reasons. But in order for another person to make normative claims on the moral agent, this other person has to be in the same context as the moral agent. In the third chapter I will expand on moral acting and the importance of a shared context.

In the fourth chapter I will argue that different contexts can have different moral rules attached to it. With the virtual world and the real world merging into one, there can be a moral confusion about which moral rules apply; a *moral vertigo*⁵. In the fourth chapter I will expand on the idea of moral vertigo and will argue that augmented reality not only merges two worlds together, but also takes away the strength of second-personal reasons. Second-personal reasons should favour the real world over the virtual worlds, but if the strength of these reasons is lost, a moral vertigo only intensifies. Augmented reality not only takes away the strength of second-personal reasons, it furthermore affects the other reasons to act morally. The context provides us with certain reasons, but augmented reality alters the context, and thus the reasons to act a certain way. In the fifth chapter I will argue that augmented reality might not only misrepresent reality, but more importantly mis-present reality. Augmented reality could show reality in a biased way, displaying only what we want to see. In the final chapter I will address the concern that virtual misbehaviour might cause actual misbehaviour. The possible bad example a virtual world might set becomes quite realistic if it is portrayed onto the real world. But augmented reality furthermore makes our virtual behaviour also actual behaviour. Instead of letting you control a virtual character, you are the 'virtual' character.

⁵ I borrowed the term '*moral vertigo*' from an essay of Chantal Steegers & Frans Brom, who wrote a more general article about moral vertigo concerning virtual worlds. (Steegers, Chantal; Brom, Frans. "Moral Vertigo". In: *Flux Magazine*, No 3, pages 15-18, 2011)

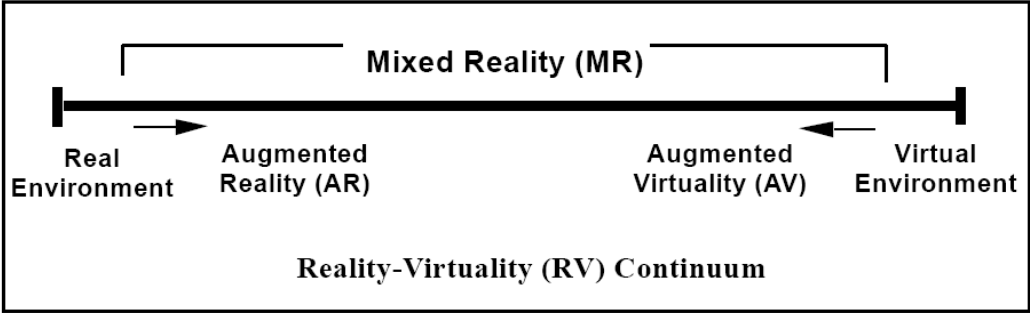
Chapter I – What is Augmented Reality?

MORPHEUS

What is real? How do you define real? If you're talking about your senses, what you feel, taste, smell, or see, then all you're talking about are electrical signals interpreted by your brain.

So far you might have a vague idea about augmented reality. In this chapter I will try to explain what augmented reality is, by using a spectrum that Milgram et. al. have developed (see Fig. A). Augmented reality according to this spectrum is placed somewhere between reality and virtuality (virtual reality). The purpose of this chapter is to develop a definition of reality, virtuality, and augmented reality

Figure A - Milgram's Reality - Virtuality Continuum



I.1 – Reality

What is reality? I started this chapter with a quote from Morpheus, who asked himself the same question. As he explained, if you define reality as the world you can perceive through your eyes and other senses, reality is basically just some electronic pulses your nerve-system is delivering to your brain. Our senses are however limiting our vision of reality. Have you ever seen the full scope of reality? New scientific discoveries constantly prove we are unable to see everything. Without a microscope, we would never have known that a grain of sand is made up out of many atoms. And even these atoms are made out of smaller parts. Who is to say that there might not even be smaller parts than that? Like the tiniest particles, we are also not aware of the bigger picture. We only witness what our senses tell us, unaware of what other things exist out there. Are we sure aliens are real? And is there something outside of the universe? Even of the things which are a part of our limited reality, we only know a little. If we accept humans have five senses (sight, hearing, touch, smell, taste), we only use some of these sense to capture an object. You might feel your laptop, touch it while you type, but how many times have you tasted it? We do not go around licking everything we see. Our perception of reality is therefore extremely limited. But if we cannot fully understand reality, how can we define it?

Reality is out there, we are just limited to our understanding of reality. Although movies try to trick us in believing otherwise, we are still unable to walk through walls, are held down on earth by gravity, etc. But we can only perceive reality through our senses. We can therefore only define our perception of reality. I believe it features three components. First of all, reality is limited to the **physical space** we are in. As I am writing this thesis, only the room I am in, and the objects in that room, is part of my reality. Although I am aware of the world outside, I do not know what is going on out there. I might have been in another room before, but that does not imply this other room is part of my reality. It is only part of my imagination, just like dream-worlds. I believe reality also has a **temporal** component. I only know what is real in a certain space at a certain moment. The future is obviously unpredictable, making it difficult to say whether a certain space will be the same in the future. A similar argument can be given for the past. Where I was before does not give me an awareness of what is happening there now. I only know how it has been. Therefore it cannot be real. The past and future do however play a role in determining the **perception** of reality. Like I said, we are only aware of what our senses tell us. Our reality is therefore limited by what we see, hear, taste, smell and feel. What my senses are telling me of a certain space at a certain time, is partially determined, or defined by what I have learned in the past, or believe to happen in the future. This makes any perception of reality uniquely personal. What my senses tell me about the room I am in might differ from what your sense would tell about the same room. We both witness the same objects, but their meanings, and how they taste or feel, might differ. I love dogs, but you might loath dogs. We would both look at the same object, a dog, but still interpret it differently, either as something we like, or disgust.

I.II – Virtuality

So far I used the term 'virtual' quite loosely, using it for nearly every computer-generated form of data or imagery. That would mean that literally everything that a computer generates, is virtual. Is this true? Not according to Philip Brey, who defined virtual reality as "*a three-dimensional interactive computer-generated environment that incorporates a first-person perspective.*"⁶ A bit incorporated in this definition is the idea of *immersion*: you have to feel like you (through a first-person perspective) are inside the virtual world (three-dimensional computer-generated environment). There are several distinguishable features in this definition that differs from 'normal' computer activity. First, it has to be interactive. The virtual world needs to respond to your commands. A computer requires man-made input telling it what to do. But normal computer activity would not require a computer to interact with a human being. By giving

⁶ Brey, Philip. "The ethics of representation and action in virtual reality". In: *Ethics and Information Technology*, 1, 1999, page 5

a computer a command, it shows you the result of that command, but not necessarily enables you to reply to that command. When you visit a website, you can either read it, or leave it. Therefore interaction is not 'normal' computer activity. Second, virtual reality needs to be three-dimensional. The virtual reality has to be 3D, in order to make it feel real, feel like an alternate reality. And third, it needs to have a first-person perspective. You have to feel like *you* are in another reality that you can walk around somewhere else. The virtual reality has to be your alternate reality.

For the purpose of this thesis the definition offered by Brey is too narrow. Although this would normally be a plus, it does not do justice to the wide scope of virtual reality. The main point of virtual reality is offering another reality to its user, through computer-generated means. Whether these means are 3D or first-person seems irrelevant. Letting someone immerse into another reality is in part a matter of perception. Some create an alternate reality through reading a good book. Just think of books like '*Lord of the Rings*' which allow you to create an imaginary world in your head.

In his book on the metaphysics of virtual reality, Michael Heim offers an overview of several components used to define virtual reality. Besides immersion and interaction definitions of virtual reality could include full-body immersion, artificiality, simulation of real life, telepresence and networked communication. Heim defines virtual reality as "*convincing the participant that he or she is actually in another place, by substituting the normal sensory input received by the participant with information produced by a computer.*"⁷ Although this definition is quite broad, it captures exactly what I think virtual reality is all about. Unlike Brey, it does not emphasise the use of three-dimensional graphics, or first-personal perspectives. The emphasis of virtual reality should be on immersion: letting the participant believe she is actually in another place.

I.II – Augmented Reality

So far I have defined reality as a combined perception of time and physical space, and virtuality as the immersion into a computer-generated alternate reality. Where do we place augmented reality? If we recall Figure A, we see that augmented reality is on a spectrum between reality and virtuality (virtual reality), together with augmented virtuality. Both augmented virtuality and augmented reality are some sort of mixed forms of reality and virtuality. In its basic form, augmented virtuality allows the real world to interact in a virtual reality (recall Microsoft's Kinect from the introduction), and augmented reality allows the virtual world to interact in the real world. Augmented reality "*allows the user to see the real world, with virtual objects superimposed upon or*

⁷ Heim, Michael. *The Metaphysics of Virtual Reality*. New York/Oxford: Oxford University Press, 1994, page 160

composited with the real world. Therefore, AR (augmented reality) supplements reality, rather than completely replacing it."⁸

In a magazine published by Boeing, Memi defines augmented reality as *"a machine vision and computer-graphics technology that overlays graphic additions on views of the real world. The hallmark of AR (Augmented Reality) is that the graphics are spatially registered; that is, they are positioned in the viewed scene relative to the positions of actual objects."*⁹ In this definition, augmented reality is limited to graphical additions to the real world. Azuma argues that augmented reality does not need to be limited to visual additions, but might be applied to all senses. He argues that so far researchers have focussed on *"blending real and virtual images and graphics"*¹⁰, but that augmented reality could be extended to include sound. *"Another example is haptics. Gloves with devices that provide tactile feedback might augment real forces in the environment."*¹¹ In order to avoid limiting augmented reality to specific technologies, Azuma defines augmented reality as systems that have three characteristics: augmented reality 1) combines real and virtual; 2) is interactive in real time; and 3) is registered in 3-D¹². Azuma furthermore argues that augmented reality does not only has the ability to add objects to the real world, but also the possibility to remove them. *"Current work has focused on adding virtual objects to a real environment. However, graphic overlays might also be used to remove or hide parts of the real environment from a user. For example, to remove a desk in the real environment, draw a representation of the real walls and floors behind the desk and "paint" that over the real desk, effectively removing it from the user's sight."*¹³

In short, augmented reality allows you to witness reality, only to add a virtual layer between you and reality. You are able to see virtual objects, which are attached to, and interacting with reality as you perceive it. It allows people to attach information to certain real objects, or display virtual items *as if* they were actually there in reality. It is important to realize the interaction with reality. The technology not only adds a virtual object randomly in your eyesight, but actually places the object in your sight based on where real objects are located, and in real-time. You see virtual things as if they are right there, in front of you. It could enable you to 'photoshop' what you see into what you want to see.

⁸ Villagomez, Gianpierre. Augmented Reality. [Lecture notes] *EECS 741: Computer Vision*, University of Kansas, 2010

⁹ Memi, Ed. "Now See This; Boeing's working on augmented reality which could change space training, ops". In: *Boeing Frontiers*, October 2006, page 21

¹⁰ Azuma, Ronald T. "A Survey of Augmented Reality". In: *Teleoperators and Virtual Environments* 6, 4, 1997, page 9

¹¹ Id., page 10

¹² Id., page 2

¹³ Id., page 9

Chapter II – Applications of Augmented Reality

Mouse

The woman in the red dress! I, I designed her. She, um... well she doesn't talk very much, but... but if you'd like to meet her, I can arrange a much more personalized meeting.

Switch

Digital pimp, hard at work.

Mouse

Pay no attention these hypocrites, Neo. To deny our own impulses, is to deny the very thing that makes us human.

In the previous chapter I have argued that reality is a combined perception of time and physical space and that virtuality is the immersion into a computer-generated alternate reality. Augmented reality is a mixture of the two, placing a virtual layer to your perception of reality. This virtual layer not only displays virtual objects in your line of sight, but also allows the virtual objects to 'interact' with the real world. Virtual objects are being placed based on where they should be portrayed in the real world. Although this might offer a fairly basic idea of what augmented reality is, I can imagine that you are still a bit clueless about the practical use of the technology. In this chapter I will firstly address the more technical aspect of augmented reality: how are we able to see a virtual layer on top of reality? The second part consists of a brief overview of the applications of augmented reality. What are the possible applications of the technology? I will end this chapter by sketching the augmented future: where does this all lead to?

II.1 – How Does It Work?

As I explained in the previous chapter, augmented reality adds a layer of virtual objects to the real world. How can it do this? Put simple: you will need to see reality, and an added virtual layer. There are basically two techniques. You could use some sort of transparent screen, which allows you to see reality, but with added virtual objects (optical see-through). Or you could capture reality with a camera, add virtual objects to it, and show the result on your screen in real-time (video see-through). (For a more extensive elaboration about these two techniques, and their (dis-)advantages, see Appendix A.). Either way, you need a computer that uses a camera to capture, or just read reality, and some additional tools like GPRS to determine your location and the angle you are looking at the real world. And you need some kind of screen that can display at least the virtual layer. It sounds rather complicated, but most smartphones

already have the tools needed for augmented reality. On the short term these devices are ideal for commercial uses of augmented reality.

The technology itself already exists, but there are still some difficulties. A first is trying to make a computer 'understand' reality and thus allow the virtual layer to interact with reality. Although computers are capable of many things, they still need computer-codes to function. Reality is however no such code, unless we 'teach' a computer how to identify an object in reality. One way of achieving this can be by simply adding visual markers to an object. These markers, known as 'tags', or QR-Codes ('Quick Response'), represent a code a computer can 'see' and understand. (For an example of a 'tag' see Fig. B.) But it would require every object in the real world to have such markers, before we can really alter reality. Another way of letting a computer identify objects in reality is by making the object 'known' to the computer. You could insert key features of an object, making the object itself a computer-code. Recall Microsoft's *Kinect*, which identifies a human body by locating key markers of the human body. Although it works quite well, it is unable to distinguish one person from another. Again, this is limiting augmented reality. How would you translate a face into a computer-code that would distinguish every human being from another? The size of their noses? Or just think of all the changing features of your face. You could grow a beard; your face gets wrinkles when older; your face changes when laughing; or crying. Trying to code the human face is a complexity that almost equals philosophical proportions. Unless every object in the real world is separately coded, augmented reality can only alter reality in a limited way.

Figure B - Example of a QR-Code



II.II – Applications

Although augmented reality has difficulties to overcome, its practical use seems limitless already. The most practical purpose of augmented reality is by providing additional information about reality. Think of navigational applications, showing you which street to take by displaying an arrow on your car-window. Or showing the location of nearby hotels and restaurants, including prices and reviews when strolling through unfamiliar cities. If facial recognition is made possible, augmented reality could even display additional information about people you meet: their names, marital status, whether they owe you money.

Professionals can also benefit from augmented reality. It could show military pilots the location of targets. Or it could show mechanics the location of car-parts and how to remove them. The similar idea can be made for medical professionals. A surgeon could look at a patient and see the patient's x-ray portrayed on her body, enabling the surgeon to precisely determine where to make an incision. Augmented reality can help to visualize

new situations, showing objects or locations faster and more accurate than the human eye. How about applications for architects: not only would augmented reality allow to determine where certain pipelines (should) run through a building, but it would also enable an architect to see how their plans would fit into the surroundings. The architect could virtually see how her plans would fit in the real world.

So far I described possible applications of augmented reality. But how realistic are they? *Layar*, a Dutch company, produces applications for mobile phones, which uses the geographical location and the camera on the phone to display additional, computer-generated information on the phone's display about the object one is aiming the camera at¹⁴. Imagine that one day, we could walk the streets, aiming our phone at other physical humans and see their *Facebook*-pages. In fact, it is already rumoured that *Google* is working on both facial recognition programs and an own social network¹⁵. In March 2011 *Nintendo* released the *3DS*, a handheld game-console, which featured an augmented reality video-game (ARGames). In their own words, "[i]magine seeing a video game unfold in the real world...right on your kitchen table, or the floor of your living room! AR Games uses the Nintendo 3DS outer cameras and AR Cards included with the system to present an amazing augmented-reality gaming experience. Just place one of the AR Cards on a table or floor, and the Nintendo 3DS camera will read the card and initiate game stages or characters right before your eyes."¹⁶ Although the initial aim of this game is to shoot fluffy coloured balls at virtual characters, just imagine when more realistic games make use of the technology. Not only could you shoot with a virtual gun, your virtual enemy could be a physical human.

Some applications already exist, and others are simply a matter of time. Just open a newspaper, or take a closer look at billboards at train stations, and the chances are high that you will find some QR-codes. Mainly these codes are used for advertisement, allowing you to see a movie-trailer when looking at a movie-poster, or direct you to the web-shop where you can purchase the item displayed. Although I argued that there are some serious limitations to augmented reality, especially in reading reality, these limitations do not pose a serious threat to the technology itself. It only slows down the development. (For a more extensive overview of the various fields of applications, see Appendix B.)

¹⁴ To be more precise, "*Layar works by using a combination of the mobile phone's camera, GPS, compass, accelerometer and a mobile Internet connection. The camera captures the world as seen through its lens and shows it on the screen. The GPS determines the exact location and the compass and accelerometer the field of view. Based on these sensors and the selected layer, digital information is retrieved over a mobile Internet connection and augmented on top of the camera view.*" (Information found on: <http://support.layar.com/entries/161321-1-1-how-does-layar-s-augmented-reality-work>; 14th of June, 2011)

¹⁵ The rumours are not just found on shady websites, even CNN reported on this rumour. (Milian, Mark. *Google making app that would identify people's faces*. CNN, 31st of March, 2011)

¹⁶ Information found on: <http://www.nintendo.com/3ds/built-in-software#/4>, 14th of June, 2011

II.III – Augmented Future - Photoshopping Reality

Augmented reality requires a computer who uses a camera to 'see' reality and some tools

Figure C - HMD Old School



to determine location and angle. More importantly it needs a screen to show virtual objects in the real world. For now most commercial use is limited to smartphones or similar devices which incorporate the requirements of augmented reality. But in the future we will be wearing head-mounted devices. Although these HMD's have been quite big and unpractical to use (Fig. C), recent prototypes are more like

average glasses (Fig. D). Imagine when the technology becomes so small, it would fit in a contact-lens (Fig. E).

Through these goggles, a (virtual) world opens up to us. We will be able to access the internet, and see it all happening in front of us. We need a keyboard you say? How about an augmented keyboard, displaying a virtual keyboard and determining the key-strokes by identifying and following

Figure D - HMD Prototypes



your fingers. We would be able to access the internet whenever and wherever we want. But not only our usage of the internet changes. Augmented reality allows us to see

additional data about real world objects. It also allows us to change reality. As an architect will be able to witness her plans becoming a (virtual) reality, we will be able to

Figure C - The Future? AR contact -lens



alter reality as well. If you look out your window, and see just boring grey buildings, augmented reality could show a beautiful forest, or display an ocean view instead. We can remove things we dislike, and replace them with things we like. Our world becomes manageable. Think of the new experience of calling a friend. You would be able to virtually display a friend as if he were sitting opposite

of you, while he actually is miles away. Or imagine when augmented reality is not only limited to visualization of things, but that we are also able to 'feel' virtual objects. Even more science fiction would be letting a computer tap into your nervous system, or brains, adding virtual stimuli. It could make a blind man able to see, albeit virtually.

But let us not drift away into movie-like ideas of augmented reality. In this chapter I have argued that augmented reality as a technology exists and that the possible applications are endless. All I wanted to show in this section is that augmented reality will enable us to alter our perception of reality, adjusting the real world with virtual objects.

CHAPTER III – And... Action!

Augmented reality alters reality. Why is this problematic? In the introduction I mentioned the idea of moral vertigo: some situations are on the border between two different contexts in which different rules apply, making it difficult for people to determine what is right in this specific situation. In the next chapter I will expand on this idea of moral vertigo. But before I am able to do so, we need to understand morality first. What makes that reality and virtuality are ultimately different contexts to which different rules apply? And what role does reality itself play in moral deliberation?

In this chapter I will make several steps. First, I will explore the concept of a moral act. What is moral acting, and what is needed to act morally? In the second step I will argue that a moral agent requires an understanding of the context in which an act is situated, and the relationship with others. Here we see how reality fits in. Reality helps a moral agent to identify the context of a situation and the relationship towards others. However, for a better understanding of the context, and thus to determine what is right in a given context, the way others perceive reality has some value as well. I will elaborate on this idea in the second and third step. If I can show that a shared perception of reality is important in making moral choices, we can see how augmented reality can be problematic. But a final step is necessary: I have to show that augmented reality really alters our reality rather seriously. I will try to do this in the last step of this chapter.

III.I – Step 1: Moral Acting

What is moral acting? First of all, there is the word acting. Action can be understood as the origination of a new state of affairs. If I close my eyes, the position changes from my eyes open (position A) into a position in which my eyes are closed (position B). The transition from A into B is the act; it is the origination of a new state of affairs (B). There is however a difficulty in such interpretation of action. If all it takes to 'act' is a new state of affairs, even breathing is acting: breathing displaces both your chest and the air you breathe. It becomes even more challenging if you add time to the equation. Time itself creates new state of affairs: the original position (A) is only that position at a specific time on a specific location. Just a second later, it is already a new position (position A + a second = position B). Even sitting absolutely still would be a form of acting.

For my story, this philosophical difficulty is interesting, but not problematic. I am discussing *moral* acting. *Morality* refers to a code of conduct, prescribing how we *ought* to behave. A moral act thus has a normative value: it can be good or bad, right or wrong. The wrongness of an action is either determined by the consequences of that action (position B is bad, utilitarian idea of morality), or the act itself does not comply

with specific given codes of conduct (the transition from A to B is bad, deontology). I will return to this normative aspect in the second step of this chapter.

A moral act further involves a moral agent who performs the act. Although time will ultimately kill everyone, the shifting of time is not considered a moral act, for time itself is not a moral agent. I believe a moral agent has to be able to choose between possible acts and determine whether an act is either right, or wrong. Time appears to only have one choice: time passes. It is also why I believe most animals cannot be moral agents. Animals might have multiple choices (a lion can either kill a gazelle, or let it live), an animal cannot deliberate on what act to choose. Rationality appears to play an important role. Imagine a setup in which pressing a red button would kill an innocent person, pressing a blue button would set him free. It is easy to see what the right act would be, pressing the blue button. Any rational human being would have to come to the same conclusion. A young child, or an animal, would not. Even if we could explain them the consequences of pushing each button, they lack the rationality to do the right thing. If they would push the red button, we do not consider *them* to performing a morally wrong act. Instead, we would view the *researcher*, who made the setup and let a child decide upon life and death, to be the one performing the morally wrong act.

In a way, we can hold a moral agent responsible for her actions. But only if the moral agent is free to deliberate. The moral agent has to have alternate choices, and the freedom to deliberate on what choice to make, to be held accountable for her actions. If all the agent has is one bad choice (consider self-defence: either kill or be killed), we cannot hold that agent responsible for making a bad choice. Although the act itself could be considered immoral, the agent is not.

III.II – Step 2: Rightness of an Act

Morality refers to a code of conduct prescribing how we ought to act. Furthermore, acting morally requires a moral agent capable of deliberating about possible actions and thus capable of determining the right act from possible alternate actions. But what makes an act right, or wrong? I have shortly mentioned that either the consequences of an action or the act itself determine the rightness of an action. H.A. Prichard argued that "*The rightness of an action consists in its being the origination of something of a certain kind A in a situation of a certain kind, a situation in a certain relation B of the agent to others or to his own nature.*"¹⁷ In this view, the consequences, '*the origination of something of a certain kind*', determine the rightness. Although I do not intend to defend this consequentialist view of the rightness of an act, I do find Prichard's definition helpful in determining some key aspects in what determines whether an act is right.

¹⁷ Prichard, Harold Arthur. "Does Moral Philosophy Rest on a Mistake?". In: *Mind*, 21, 1912, page 27

First, Prichard argues that the rightness of an act consists in the origination of something '*in a situation of a certain kind*'. It is the context that provides us the reasons to judge whether a certain act is right. For consequentialist theories, such as Prichard's, these reasons are found in the consequences of an act. An act is right if it benefits some greater good, such as the overall happiness of society. For deontological theories the reasons appear to be lodged in the act itself. If the act is consistent with some principle (for instance: thou shalt not lie), than it is justified. In choosing the right act from possible alternatives, the context helps the agent to determine the right one. If all the choices the moral agent has are bad choices, for example when talking about cases of self-defence, than she ought to do that action that causes the least possible harm. The choices a moral agent has are determined by the context. Although the moral agent might prefer a good choice, the context only offers him bad choices.

A second aspect of Prichard's definition I deem important is '*a situation in a certain relation of the agent to others or to his own nature*'. We just saw that the context is important in determining the rightness of an act, but an important part of the context is the relation of the moral agent to others or herself. What I think Prichard means is that a moral act involves a being that can be wronged with that act. Shooting a gun has no normative value, unless it is aimed at another person, or harms a person in any another way. Again, although Prichard offers a consequentialist definition of the rightness of an act, I believe this relational aspect is not limited to consequentialist theories. What differs is in what way this relational aspect affects moral decisions. For consequentialists, our duty to act morally is derived from a greater good. For example: the greatest happiness-principle holds that we should make the world a happier place in general. This means that if an act would make a dozen people happy by making one person miserable, we should commit that act. Even if that one person would be ourselves. For Kant, every rational human being has dignity, leading to his idea of humanity as an end in itself: "[s]o act that you use humanity, whether in your own person or in the person of any other, always at the same time as an end, never merely as a means"¹⁸. Humanity, as an end in itself, is an important reason to determine how we ought to act.

Kant argues out of first-personal reasons. Because we are rational human beings, we have dignity. If we have dignity, so do other similar beings around us. It is this rational deduction that should give us reasons to treat humanity as an end in itself. However, the reason originated within us: as a rational being, I deserve respect. First-personal reasons are moral reasons that originate inside the moral agent. Acting morally either is what the agent believes she ought to do, or what would be in her best interest to do. Consequentialist theories use third-personal reasons: some greater good, or society in general, provides the moral reason to prefer certain acts. Stephen Darwall, a

¹⁸ Timmons, Mark, *Moral Theory, An Introduction*. Rowman & Littlefield, 2002, page 157

deontologist, argues that although these first- and third-personal reasons might offer some reasons to act morally, it are actually second-personal reasons which provide the strongest moral reasons. In a way he follows Kant, claiming that human beings have dignity, but because they have dignity, they can expect certain behaviour of the moral agent. As I said earlier, a moral act affects another person. This person has certain interests, especially in not being harmed. Because this person has dignity, she can expect, and even claim, that the moral agent should respect her dignity. If an act harms her, she can claim that the moral agent should refrain from committing that act. Unlike Kant, the reason does not originate within the moral agent, but the reason is provided by a second-person. Darwall claims that these second-personal reasons have more normative strength than first- or third-personal reasons in determining the rightness of an act. Let me illustrate this point with an example. Some acts are harmless on their own, but gain normative value when others are involved. Having sex with your partner in the privacy of your bedroom has no normative value (assuming your partner consents to having sex). Having sex outdoors is a bit more problematic. But is it because of being outside? No, having sex on a deserted island is not problematic. Having sex on any deserted location is not problematic. Having sex in public is slightly more problematic, although in certain contexts having sex in public is even not problematic (making a porn-movie, or in adult-shows). It becomes problematic if the public is objecting to your behaviour: having sex on a public road, or on a playground filled with playing children.

Why would you refrain from sex in one context, but not in another? For Kant we should “[a]ct only in accordance with that maxim through which you can at the same time will that it becomes a universal law”¹⁹. A world in which everyone had sex in public, is that such a bad world? A porn-star seems to have no problems with it. Internal reasons would provide limited, if not opposing, reasons to prevent us from having public sex. How about third-personal reasons? If an act is justified if it would benefit overall happiness, than two people having public sex could outweigh the discomfort of some, in terms of happiness. If we would allow public sex, it might even become ‘normal’, taking away even the discomfort of some. Both first- and third-personal reasons do not appear to be strong enough to prevent us from having public sex. Second-personal reasons do. Second-personal reasons would argue that children at a play-ground, or people visiting a busy street, do not expect to see people having sex, and can be offended by you having sex in front of them. They can be harmed by your act, and because we grant them dignity, they could claim not to have sex in public. These second-personal reasons seem to be the strongest in preventing us from having public sex.

I do not deny first- or third-personal reasons; neither do I deny that these reasons can influence our behaviour. All I wish to show is that second-personal reasons appear to

¹⁹ Id., page 164

have a stronger effect when determining the rightness of an act. Most, if not all, moral acts have consequences that are either directly or indirectly affecting a second person, or persons. Their interests are morally important, if we accept their dignity as human beings. They can expect, even claim certain behaviour of us, not because of a greater good, or internal reasons, but because of their dignity.

III.IV – Step 3: A Second-Person Reality

In the previous section I have argued that the context in which an act takes place allows the moral agent to determine what act is right. The relational aspect, which is part of the context, offers second-personal reasons that help determining the right act. The other person in an act has certain expectations, certain claims she can make on the moral agent, which the moral agent is obliged to respect based on the dignity of the other. In the first chapter I have argued that reality is a matter of perception. We saw that a perception of reality is uniquely personal. Your perception of reality will ultimately differ from mine. Reality defines the context, making the context of an act also a matter of perception. It would mean that I make moral decisions based on my perception of the context, while the second person lays claims from her perception of the context. Since differences in context can account for differences in moral rules, this might be problematic. We normally believe that a soldier at war is justified to shoot his enemy. The context of war justifies the shooting. But we do not justify shooting on civilians. The claim a civilian makes is different from an enemy combatant. Although both a civilian and an enemy combatant would not want to be shot, an enemy combatant implicitly accepts a context of war, where he might get shot. But what if the enemy combatant is dressed as a civilian, or the civilian as enemy combatant? The second-personal claim remains the same, but the perception of reality differs. But does this affect the second-personal reason?

The example above does not undermine my argument of second-personal reasons. In fact, it only strengthens it. A soldier who cannot be sure whether the person in front of him is an enemy or civilian will have a difficult task deciding whether or not to shoot that person. Knowing the context of the second person only helps to decide the right thing to do. Without that knowledge, the soldier is left in a moral vertigo, confused about what the right course of action would be (I will further address the idea of moral vertigo in the next chapter). But if our perception of reality disables us from sharing the moral context, than we might never know what the context of the second person is, and thus second-personal reasons will fail. However, I doubt whether that can be the case. As I said in the first chapter, true reality is unimaginable for the human senses, but it exists. Although we might perceive things differently, we both cannot walk through walls. And through language we have come to share our perceptions, and agree on certain things. If an object looks like a bed, we can agree that it is a bed. Similarly we can agree on its

meaning: a bed is usually used to sleep on. Through learning we are able to attach meaning to certain objects, without constantly having to share our perception with others. In a similar manner we can attach moral beliefs to certain contexts. If we would walk into a room filled with books, we assume it is a library. Previous experiences with libraries would tell us that since we believe it is a library, we should keep our voices down. Although we still perceive a library uniquely personal (some would feel at ease in a library, some would feel uncomfortable), as long as we can agree on the context we perceive (a library), and agree on the moral rules that apply in this context (keeping our voices down), second-personal reasons remain their strength.

III.IV – Step 4: Time for an AA-meeting? - Augmented Addiction

In the second chapter I argued that augmented reality has the potential to alter our reality. But I just argued that a shared perception of reality is important for making second-personal claims. Is this problematic? Not necessarily. If we only use augmented reality occasionally, allowing our moral choices to be based on reality, than there is no problem. It becomes problematic if augmented reality becomes our reality, if we are no longer willing, or simply unable, to separate reality from augmented reality. I believe the technology has what it takes to become an addiction, which does make it harder to turn off augmented reality.

Why would augmented reality be addictive? It is a culmination of reasons. First, there is the human desire to seek a better world. As I started the introduction, we love to dream about a better existence, and try our best to achieve that goal. One way of achieving this goal is through immersion in an imaginary world. Radio, TV and books do spark your imagination, allowing you to dream about another existence, but these means still only allow you to passively participate in a dream world. Virtual reality already allows you to actively participate in alternate worlds. You can actually influence the outcome of the story, to some degree. But virtual reality remains an alternate reality. You still have to do your daily routine in reality, still have to get away from the virtual world at some point. But augmented reality just alters your perception of reality instead of creating a whole different world. If we accept the premise that the technology will evolve into some high-tech glasses, which enable you to shape your surroundings, then you would be able to create your own little dream world. And you would never have to leave. Would you turn off a device that shows sunny skies instead of grey clouds, luxury apartments instead of tiny student rooms? You would have the hallucinating effects of LSD, without the physical inconveniency. Drugs require taking the actual drug to get the hallucinating effect. It means that you still have to leave the imaginary world for the real world at some point. Augmented reality would be more permanent, as long as the battery is charged.

Augmented reality is furthermore a step in another process: our dependence on internet and mobile technologies such as mobile phones. These two technological developments did not just improve our ability to access information, and stay in contact with faraway friends, but they became an important aspect of our daily lives. It is almost impossible not to be connected to the internet. Even if you do not own a pc, or have access to internet, the odds are that some of your data is still 'online'. Just think of governmental or medical records that are increasingly accessible through the internet. Mobile technologies only made it easier to access the internet. Wireless networking, Wi-Fi hotspots, mobile internet-services, all make it easier to access the internet nearly wherever, whenever.

Only two decades ago only a happy few owned a mobile phone. Nowadays it are only a few who lack one. In the beginning a mobile phone was just that, a mobile phone. We could only call people. But the newest smart-phones allow you to call, text, access the internet, take pictures, keep a digital agenda, play games, and even use it as a navigational tool. These phones are becoming a vital part of our (social) lives. With applications such as Skype, Ping and WhatsApp we can stay in close contact with friends all over the world, without significant financial costs. Social media such as Facebook are no longer about staying in contact with others, but are becoming social gathering-points. And it is addictive! How many people switch off their phones at night? I personally sleep with my phone, using it to check my mail before going to sleep and when waking up. People actually feel uncomfortable when their service is out of reach. They no longer are 'available' to answer calls, or answer mails, creating a feeling that they are missing out on important calls.

As I already mentioned earlier, public use of augmented reality is for now closely linked with mobile technologies such as smartphones, which have the necessary tools for augmented reality to work. If augmented reality will evolve into high-tech glasses, there will be a turning point where augmented reality is no longer incorporated in smartphones, but smartphones will be incorporated in these glasses. New generations will grow up with augmented reality, as I grew up using mobile phones and the internet, not knowing how to live without it. In a way it incorporates the addictiveness of staying in contact with the world (through internet and mobile technologies) with the addictiveness of hallucinogenic tools (such as certain drugs). Why would we want to turn it off? We do not have to. Augmented reality allows us to be active in the real world, but alters it. It might take a while for the technology to evolve, and for us to get familiar with it. But once we are used to it, we will be hooked. Turning off augmented reality will still be optional, but less and less the desirable option.

III.V – Quick Overview

The main conclusions that can be taken from the first two steps are that the context of an act provides normative reasons for the moral agent to determine the rightness of an act. Part of the context is the relation of the moral agent to others. These others provide second-personal reasons to act morally by laying (implicit) claims on the moral agent, claims they are allowed to make based on their dignity as human beings. In the third step I argued that the claims others make require both the moral agent and these others to be in the same perceived context. Although this might be problematic given the unique perception of reality sketched in the first chapter, I argued that a shared perception of the context is nonetheless still possible. Augmented reality has the potential to alter our perception of reality. For moral deliberation this does not have to be a problem, as long as our moral choices are still made based on reality. However, in the final step I argued that augmented reality is potentially addictive. Although it might still be optional to turn it off, I argued that we might be less willing to actually turn it off. If that would be the case, augmented reality alters our reality more permanently, affecting our moral deliberation in the progress.

Chapter IV – Moral Vertigo

CYPHER

You know, I know that this steak doesn't exist. I know when I put it in my mouth, the Matrix is telling my brain that it is juicy and delicious. After nine years, do you know what I've realized?

(...)

Ignorance is bliss.

In the previous chapters I have argued that augmented reality has the ability to affect our perception of reality, and that the context of an act provides normative reasons to determine the rightness of an act. Second-personal reasons, provided by others in a moral act, appear to have the greatest normative strength. But to what conclusion does this lead? What will be the effect of augmented reality on our moral deliberation? In this chapter I will argue that augmented reality takes away the second-personal reasons to act morally, adding to a *moral vertigo*: confusion about what moral rules apply to specific contexts.

IV.1 – Explaining Moral Vertigo

As said, the moral agent determines the rightness of an act based on the context in which the act is situated. Different contexts allow for different moral codes of conduct. One type of context which rules differ from daily life is a context of play. Games have specific rules, sometimes rules that are opposite to our normal moral rules. Think of a boxing-match: punching someone for no particular reason normally is morally unacceptable. The context of a boxing-match makes punching suddenly acceptable. We usually have no difficulties identifying the right rules. Specific markers enable us to identify a context as a boxing match: boxing gloves, a boxing ring, the referee, etc. Although two people entering a boxing-ring might both accept the context as a boxing-match, since they share the same reality, their perceived context might still differ. Each person has a unique position within a certain context. If a young child would to enter a ring with a heavy-weight boxer, we would still find it morally unacceptable if the boxer punched the kid, even though all the markers are in place. Again we see the importance of a second-personal claim. It is not just the context which both persons entering the boxing-ring need to agree on, it is also the relation between the moral agent and the other, their relational position in the context, that matters. Although the child might perceive the context as a boxing-match, from her point of view, she is not, or should not be competing with the heavy weight fighter.

As mentioned, acts of play have different moral rules than in real life. The word 'play' encompasses more than just games and sports. Steegers & Brom use the word 'play' also to encompass 'performances', like acting. Consider the dominatrix in an SM-play, where beating and torturing suddenly appears justified. But sometimes it is not clear whether a certain act is a play, or real. How about 'reality shows': is it acting, or is it real? To attract viewers, parts at least appear to be acted. But these shows are supposed to portray the daily life of its 'actors'. In a way, these shows serve as some sort of role model. If the people on these shows use foul language on a regular basis, or constantly fight each other, then people like us might believe that this behaviour is 'normal' behaviour. Because we are not sure whether it is real, or an act of play, we are confused whether we should apply rules of the real world, or of a context of play. The diffuse separation of the two worlds is described using the term moral vertigo: "a *confused, disorientated state of mind and morals*"²⁰. To be more specific, moral vertigo refers to the borderline between the two worlds, situations in which it is unclear to the moral agent which rules apply to that specific context: do we apply rules of play, or rules of the real world?

But the idea of moral vertigo is not limited to the grey area between play and reality. There are more borders to be thought of. Steegers & Brom also mention a separation between the virtual and physical world. Virtual worlds appear to have their own moral codes of conduct. The killing of others is considered at least *prima facie* wrong in the real life, but appears to be obligatory in most games. There are still times when virtual worlds are testing the boundaries of our moral beliefs. In the video-game *Carmageddon*, the player can score a bonus for causing havoc on the public road: driving over animals, old ladies with strollers, even mothers with children (in the later versions) can give you extra credit. In *Manhunt* you even score points for the creativity in which you kill others. Both games turned into considerable public and political debates, and in some countries one or both games were even banned²¹. Another interesting case was when people created child-like avatars in *Second-Life*, and used it to have (paid) virtual sex with virtual adults²². Child-pornography or simply fantasy-gone-wild? The latter example shows the difficulty to separate virtual rules from normal rules. Through social media a physical person is transformed into a virtual character. These virtual characters are playing an increasingly more important aspect of our daily life. Job-recruiters are checking out the

²⁰ Steegers, Chantal; Brom, Frans. "Moral Vertigo". In: *Flux Magazine*, No 3, 2011, page 15

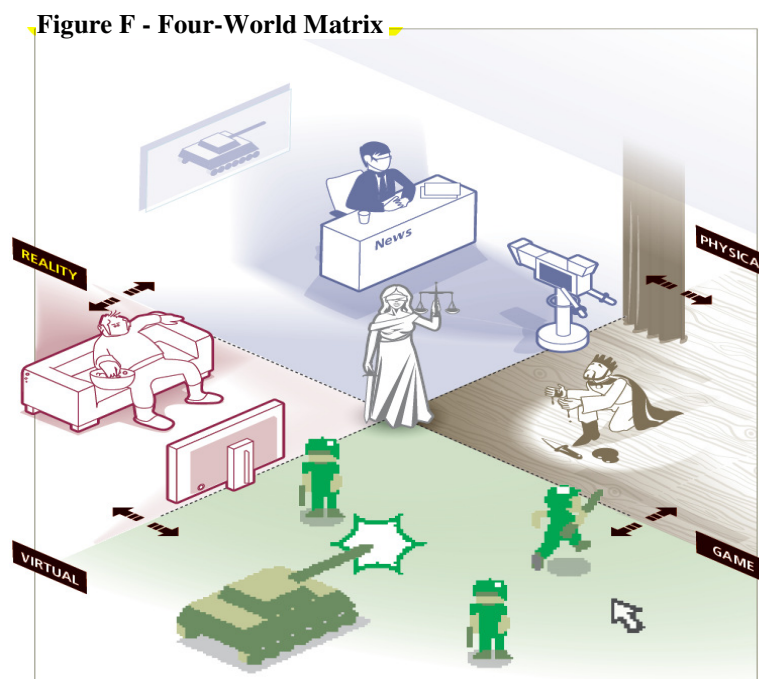
²¹ In 1997 SCI, the manufacturer of *Carmageddon 2* won an appeal, lifting the ban on the game in the UK. (Unknown Author. *Carmageddon smashes British censor ban*. BBC, 4th of November, 1997) In 2004, *Manhunt* was believed to have inspired a teen to kill a friend. (Unknown Author. *Manhunt game withdrawn by stores*. 29th of July, 2004) In 2007, *Manhunt 2* was banned from the UK. (Howson, Greg. *Manhunt 2 banned*. The Guardian, 18th of June, 2007)

²² The issue led to a debate in the Dutch Parliament in 2007. (Unknown Author. *Kamer wil verbod op kinderporno in Second Life*. NRC Handelsblad, 21st of February, 2007, re-edited on 22nd of August, 2008)

online profiles of possible candidates to see whether they would fit the job. But do our online profiles present an accurate picture of who we are, and what we are capable of? With virtuality taking more control over our reality, separating the two becomes even less clear

Steegers & Brom use the opposing contexts of virtual and physical, and reality and game to describe the term moral vertigo. They argue that these different contexts are becoming more and more diffuse and overlapping. People are left confused about what moral rules should be applied in cases where different contexts are overlapping. Combined, these four contexts lead to four different 'worlds' in which different rules seem to apply (see Fig. F). There is the physical reality, the physical context of play (or game), the virtual reality, and virtual games. I assume Steegers & Brom to use the world 'virtual reality' to describe reality that occurs in a virtual world, such as social media. In this context, some of the rules of the physical world triumph over rules in the virtual world. Threatening to kill someone on Twitter can be morally wrong, while threatening to kill someone in a virtual game has no moral meaning, given that the aim of the threat is a virtual character. But here we already see the grey area between the different worlds. When is a virtual threat real, or simply a game, or playful comment?

As I argued, moral vertigo emerges when two contexts in which different moral rules apply appear to be overlapping, creating a grey area in which it is not clear what rules should be applied. But the idea of moral vertigo does not have to be limited to the four worlds used by Steegers & Brom. A soldier at war is neither in an act of play, nor in a virtual world, but she can still be in a moral vertigo. As I already described in an earlier chapter, the soldier has to decide who his enemy is. Urban warfare or the terrorist that could be your neighbour, all make it difficult for a soldier to separate war from normal ways of life, and his enemy from an ally.



IV.II – Augmented Vertigo

Augmented reality adds a virtual layer on the real world. If there is a moral vertigo at the border between virtuality and reality, augmented reality is at the frontline. Steegers & Brom appear to draw a similar conclusion: *“Not only aboard a tank the difference between the virtual and the physical is fading extremely. ... It also happens when smartphones give tactile feedback or place a virtual information layer over physical reality (augmented reality).”* Augmented reality in a way functions as the border between the real and virtual world. It merges the two together. With the merging of two worlds, it also merges two different sets of codes of conduct together.

In the third chapter I argued that a moral agent requires the context of an act to determine the rightness of an act. The context provides reasons to act a certain way. Part of the context is another person, or persons, who make (implicit) claims, which provide strong (second-personal) reasons to act upon. But to make valid claims, the second person needs to be in the same shared context as the moral agent. Augmented reality allows people to be in their own augmented world, which is exclusively theirs. It is their reality mixed with virtual objects. Through personal shaping of the world, augmented reality creates a unique perception on reality, which is only visible to the user. You do not live in a shared world, or a shared alternate world, but your own world, which is difficult to share. This creates first of all a practical problem. In any normal situation, starting to laugh at some stranger passing by is not nice. Augmented reality could make you look at a stranger, but laugh at some virtual imagery displayed in your line of sight. But the stranger still feels laughed at. He is not aware of how you perceive reality, and that it is not him you are laughing at.

Augmented reality weakens second-personal reasons. Without a sharing of a perception of reality, the expectancy others have, the claims they make onto our behaviour, loses its value. But is this important? People might still have other reasons, first- or third-personal, that can lead to good conduct. However, without the normative power of second-personal reasons, it is doubtful whether other moral reasons can have sufficient power. If you would take away second-personal reasons moral reasoning loses strength. Recall the example of having sex with your partner. First- and third-personal reasons could be twisted in accepting the premise that it would be good to have sex in public. And you might have a personal interest in having sex in public (if it turns you on). Without second-personal reasons you would be not only in a vertigo determining what the right thing to do is, but also whether you should do the right thing at all.

Even without a vertigo between different sets of reasons augmented reality offers yet another problem. The context of an act helps us to determine the rightness of an act. Augmented reality alters how we perceive reality. It creates, or recreates reality in a way that may be false, or prejudicial. Attaching a personal profile to people’s faces would

allow me to see race, sexual orientation, etc., which could affect my judgement of people. This can be problematic in bars (you will only try to meet people that fit your profile), or in the streets (avoiding people that are gay). Or you would not visit restaurants and hotels, due to some bad reviews years ago. The information augmented reality is providing you might be false, or mis(re-)presenting reality. A false image of reality does not only negatively influence second-personal reasons, but first- and third-personal reasons as well, since the content of these reasons is determined by the context. You would rely on bad information when making your moral judgement. In the next chapter I will further expand on this problem of mis(re-)presentation.

Another problem of augmented reality is that it might lead to moral misbehaviour. In the previous section I already briefly addressed the worry that acts of play might set a bad example. Augmented reality would not only set a bad example, but through augmented reality you would be committing an act directly instead of indirectly. The bad example is no longer virtual, but real. In a virtual surrounding, you are guiding a virtual character, who does virtual bad things. But you are just using a keyboard. Augmented reality uses you as a controller. Not a virtual character, but you do virtual bad things. I will further expand on this problem in chapter VI.

IV.III – Concluding Remarks

Moral vertigo is a term used to describe the confusion arising from a diffuse mixture of worlds in which different moral norms apply. You behave differently amongst friend than you would while working. But when work is mixed with friends, how formal would work be? Virtual reality attaches different moral codes to similar contexts. What is forbidden to do in the real world becomes acceptable in the virtual world. You could argue virtual worlds to be a different, virtual context. However, augmented reality mixes the real, physical world with the virtual, creating a confusion whether virtual or physical norms apply to a situation. This can cause practical problems, when you are not sure whether something is virtual or not. But it could also lead to a misrepresentation, or misrepresentation of reality. In the next chapter I will further address this problem. Another problem could be through behaviour. Since augmented reality allows you to be the virtual character, virtual behaviour becomes actual behaviour. In the final chapter I will address that problem.

Chapter V – (Re-)Presentation of Reality

The concerns that virtual behaviour or misrepresentation of reality can have ethical implications are addressed by Philip Brey. Although he addresses both concerns when speaking of virtual reality, the previous chapter briefly showed that they could also be applied to augmented reality. I will argue that both concerns not only apply to augmented reality, but that they are actually worse for augmented reality. In this chapter I will start with the concern of misrepresentation, arguing that augmented reality could also lead to a mis-presentation of reality.

V.1 – Misrepresentation

According to Brey, virtual reality makes certain 'reality claims'. The more realistic the application tends to be, the more accurate it must portray reality. But what one aims to portray also depends on what goals the application is trying to achieve. If you try to create a virtual version of Amsterdam, what you actually want to portray depends on whether you want to make a tourist-guide of Amsterdam, or some navigational tool. A tourist-guide requires a more accurate portrayal of the major tourist attractions, while a navigational tool would require the distances between two points to be more exact.

In trying to represent a certain aspect of the real world (like Amsterdam), there is a risk of misrepresentation. Virtual representations of the real world tend to leave out information about an object, causing a misrepresentation of that object. If you want to make a tourist-guide of Amsterdam, would you portray its coffee shops and the red light district? The city of Amsterdam would rather not emphasize on these 'tourist-attractions', but leaving them out of a virtual tour would clearly misrepresent touristic Amsterdam. And how realistically do you want to portray reality? How would you display the red light district? To make an accurate portrayal, you would not only need to show the buildings, you would need to display the women behind the windows as well. Without the women, the red light district would just be an average street in Amsterdam.

Besides the risk of misrepresentation, there is also the risk of *biased representation*. Again, if you were to display the women of the red light district, you could show a detailed version. But we want to keep the application PG-rated, so you have to represent the ladies in another way. You could make use of comical representation, or dress them up. The latter will again be misrepresenting them, for they would just be some ladies in a window. A comical representation however might stigmatize their profession. The application "may induce false or biased beliefs in users that may ultimately have undesirable practical consequences."²³

²³ Brey, Philip. "The ethics of representation and action in virtual reality". In: *Ethics and Information Technology*, 1, 1999, page 12

V.II – Mis-presentation

Misrepresenting reality in virtual worlds could lead to biased ideas about reality. It might be a concern for virtual worlds, but it is a problem for augmented reality. Remember again the shallow separation between virtual worlds and the real world. Any misrepresentation of reality through virtual objects is now directly linked with the real object. The most basic idea: using an application of augmented reality while shopping, to display sales-items of each shop for instance, could enable you to be more specific where to shop. But it would also direct you to the shop that has the highest sales-rates, or keep you away from small shops that do not work with augmented reality, therefore not displaying their sales in virtual layers. These shops might have better sales, or better products, but by not being represented in the virtual layer, they are losing customers.

Although this example is troublesome for smaller shops with limited budget, you could argue that it requires shop-owners to adapt to the modern world. It does show the initial worry that augmented reality might not show all relevant information, but only a biased part of it. It gets more problematic when we rely on augmented reality too much. BMW is working on an application that helps mechanics to search for parts and even gives them instructions on how to remove those parts. This might create 'dumb mechanics', who know nothing more about cars than what augmented reality is telling them. Similar ideas can be developed for medical use. Surgeons could be shown where a tumour is located, and where to make incisions to remove it. But we do not want to imagine a similar development of 'dumb surgeons' who operate only based on what a computer is telling them. This is extremely worrisome when computer glitches shift the location of an incision just an inch. On the other hand, augmented reality could step in when humans fail. If the surgeon would suffer from a heart-attack during a surgery on another patient, augmented reality could help a nurse to take over the surgery.

Brey's concern is on misrepresenting reality, because virtual reality creates an alternate reality in which the real world is copied (to some extent). Augmented reality however is not trying to copy reality, but adds virtual objects to reality. It might misrepresent certain stores through bad or limited information, it can also present reality differently. We could recreate our reality, showing a beautiful forest over wasteland, a shiny blue sky over dark grey clouds, or change people's appearance into the love of your life. It might be a practical problem, when you forget your raincoat on a rainy day because all you see is sunshine, but also a moral problem. Altering reality could also alter the context of an act. Though altering reality a context can shift from morally wrong to morally justified. If you augment a bar into a boxing-ring, you could make a bar-fight into a boxing-match. Or you could stare at a physical child, and virtually see a naked child instead. Augmented reality can thus mis-present reality. Through altering reality it alters the context of our actions. Since the context provides us with normative reasons,

first-, second-, and third-personal, to act a certain way, a mis-presented reality affects our moral judgements.

V.III – Concluding Remarks

Brey argued that virtual reality can lead to a misrepresentation of reality, or a biased representation. Augmented reality can also misrepresent reality, but now displaying the misrepresentation directly onto reality. It furthermore allows you to alter your own reality, and thus possibly mis-present reality. Reality becomes manageable. This creates a practical problem, when there are inconsistencies between reality and the altered reality. But the altering of reality more importantly affects our moral judgements. Through changing reality also the perceived context of our actions changes. In the third chapter I have established that the context of our actions is providing us with normative reasons to act a certain way. A mis-presentation of reality would therefore alter the normative reasons, negatively affecting our moral judgements.

Chapter VI – Virtual Behaviour - Augmented Behaviour

The second ethical concern Brey raised about virtual reality is actually two-fold. First, virtual misbehaviour can cause real harm; second, virtual misbehaviour can cause real misbehaviour. I will start this chapter by addressing both problems as Brey sees them. In the second section I will not only argue that the same concern could be applied to augmented reality, but also that augmented reality makes virtual behaviour more real.

VI.I – Setting a Bad Example

I will first address the concern that virtual behaviour can have consequences in the real world. I will secondly argue that virtual behaviour can inspire real behaviour.

VI.I.I – Virtual Behaviour has Real Consequences

Imagine a game in which you play a Nazi-soldier, trying to achieve a Third Reich through hunting down and shooting Jews, maybe even using gassing chambers. The game itself might disturb the Jewish community, but also us playing the game, our virtual behaviour, might cause them to be offended. Through playing the game, we stigmatize and even discriminate a physical group of people, the Jews. The interesting conflict is here between the freedom of speech, or expression and thought, and the right not to be offended. We could agree that the freedom of speech is not unlimited, that some words or some expressions are offensive and should be prohibited. But where to draw the line? Should we prohibit jokes about dumb blondes, because they stigmatize blonde women? And our opinions on what is offensive change over time. Some words or symbols that did have no meaning before can become meaningful due to certain events. The Nazi-cross was used by the Romans in historical times, and only received an offensive meaning due to the atrocities of Nazi-Germany. And the offensiveness of some things changes due to acceptance over time. Consider homosexuality, which was (and sometimes is) considered blasphemous, but now is becoming increasingly accepted in a growing number of countries. However, these considerations do not take away the concern that behaviour in virtual worlds can cause harm in real life. It only shows the difficulty of drawing an ethical line between good and bad virtual behaviour.

VI.I.II – Virtual Behaviour Inspires Real Behaviour

The concern that misbehaviour in virtual worlds can inspire misbehaviour in the real world is often raised. There have been many instances in which misbehaviour in the real world is ascribed to, for example, violent videogames. In the news coverage of the Columbine shooting and even the recent Alphen a/d Rijn shooting it was claimed that videogames inspired the shooters²⁴. The violence in these games offered the gunmen

²⁴ The Dutch Newspaper AD (Algemeen Dagblad) mentioned that the Alphen a/d Rijn-shooting had many similarities with the video-game Call of Duty: Modern Warfare 2. (Unknown Author. *Bloedbad*

target practice and made them believe there was nothing wrong with violent killings. But then again, the 9/11 terrorists used a flight simulator to train their pilot skills. Would we say that flight simulators are the root of their evil as well? And millions of people play violent games each day, only some who take up the idea in real life. Back in the days the same line of reasoning was used to discard violence on TV, or even radio. When *'War of the Worlds'* was first played on the radio, some people actually believed the world was at war with aliens. Music caused revolutions, sparking ideologies that were considered as evil. Remember the influence of things like *Rock 'n Roll*, *Flower Power*, *Woodstock*, *Live Aid*.

However, unlike movies and radiobroadcasts, which only allow you to passively witness the fictional violence, virtual worlds allow you to be actively involved in the fictional violence. This leads Brey to consider a Kantian explanation. Kant holds that "[...] *he who is cruel to animals becomes hard also in his dealing with men*" and "(t)ender feelings towards dumb animals develop humane feelings towards mankind."²⁵ In short, Kant holds that violent behaviour towards animals will result in an equal treatment of human beings. We have an imperfect duty to strengthen feelings of compassion, which is affected when we are cruel to animals. Feelings of compassion enable us to promote morality towards other human beings. When we are cruel to animals, we negatively affect our feelings of compassion, what could lead to a lack of compassion when dealing with other human beings. Animals are in some way close to us humans; they represent a part of our humanity that allows us to transfer feelings of compassion from an animal to a human.

A same line of reasoning could be applied for virtual worlds. A virtual character is also closely connected to a human being, for it is a representation of a physical person. A virtual character both resembles a human in many aspects, and is operated by a human. Therefore, cruel behaviour towards virtual characters can have similar Kantian effects as cruelty to animals. However, this argument requires, as Brey rightfully claims, empirical support. How much does cruelty to animals, or virtual characters, really influence our behaviour? If it even influences our behaviour at all.

Tristan lijkt griezelig veel op computerspel. AD (Algemeen Dagblad), 12th of April, 2011) The families of the victims of the Columbine shooting were less cautious and actually sued a total of 25 gaming companies, claiming them to be responsible for their tragic loss. (Unknown Author. *Columbine families sue computer game makers*. BBC, 1st of May, 2001)

²⁵ Brey, Philip. "The ethics of representation and action in virtual reality". In: *Ethics and Information Technology*, 1, 1999, page 9

VI.II – Being the Bad Example

The concern of virtual behaviour gets a different meaning when speaking of augmented reality. Virtual behaviour is what you do in virtual surroundings. In augmented reality there cannot be virtual behaviour. You do not operate a virtual character through a controller, or keyboard, but you are the character yourself. Hitting a virtual opponent would require that you actually hit something, or the air. The intensiveness of this virtual, but real behaviour therefore increases. With a growing level of realism of virtual objects, and the decreasing separation of the virtual world and the physical world, the line between virtual misbehaviour and real misbehaviour becomes awfully thin. Imagine a shooting game in augmented reality that is so realistically, that it actually looks like you are shooting people. It will become harder and harder to distinguish virtual misbehaviour from real misbehaviour. Here we once again see the idea of moral vertigo emerge. When people can no longer separate virtuality from reality they will be confused about the right course of action. This confusion only increases the chances of physical action being inspired by virtual actions. Augmented reality not only adds to moral confusion about what is right or wrong, but also adds real, practical confusion. Would you be able to distinguish a virtual character from a real person, when both appear quite real? In that sense, the possibility of augmented reality to cause real harm only increases. Since augmented reality makes virtual behaviour real behaviour, it becomes more visible, and physical, to others. Instead of playing in the privacy of your home, your virtual behaviour could take place out in the open, for all to see.

For now, the level of realism of virtual objects is not that high that we will have difficulties distinguishing real from virtual objects. But there is still reason to assume that the concern that virtual misbehaviour can lead to real misbehaviour is stronger for augmented reality than for virtual reality. Just think of creating your own Third Reich: you could display Nazi-symbols on buildings, and even add Jew-stars to people with big noses. You would be living inside your own fantasy, but at the same time actively participating in the real world. As long as you do not act like Hitler, or use the technology to discriminate people, there appears to be no problem. But it does make you think about the 'benefits' of augmented reality.

Conclusion – Towards the Matrix?

MORPHEUS

The Matrix is everywhere, it's all around us, here even in this room. You can see it out your window, or on your television. You feel it when you go to work, or go to church or pay your taxes. It is the world that has been pulled over your eyes to blind you from the truth.

NEO

What truth?

MORPHEUS

That you are a slave, Neo. That you, like everyone else, was born into bondage ...
... kept inside a prison that you cannot smell, taste, or touch. A prison for your mind.

Augmented reality, a bliss or sin? No matter what your opinion about it, the fact remains that the technology is coming. We will one day wear glasses that enable us to see an altered reality, I am sure of that. In this thesis I have shown that it can have some very interesting applications, with lots of benefits. But I have also tried to show that there are some concerns that need to be taken seriously. Augmented reality offers us the ability to alter the way we perceive reality. It does not just display virtual objects, but attaches these objects to the real world, creating a manageable world. We can virtually change everything into anything. But it is not without any danger.

To determine the rightness of an act, the moral agent requires the context of that act to provide her with reasons that enable her to make a moral judgement. Part of the context is a relational aspect: a moral act seems to involve another person that is affected by the act. To determine the rightness of an act, the context provides the moral agent reasons that might come from within herself (for example rationality), or a greater good (for example the overall happiness of a society), the strongest reasons are provided by the other person. This second person, or persons, can make certain claims of the moral agent to respect her interest, her dignity as a human being. These second-personal claims provide the moral agent with second-personal reasons that appear to have a stronger normative strength than first- or third-personal reasons to determine the rightness of an act.

Augmented reality alters reality. This creates several moral problems. First of all it creates a moral vertigo. With the mixture of virtual objects into the real world, the separate rules that apply to virtual worlds and the real world become intertwined,

creating a confusion about which rules are right. A moral vertigo is not only achieved by a diffuse separation of moral contexts, but augmented reality also weakens the second-personal reasons. People are no longer able to share the perception of the context. Claims a second-person makes are stemming from a different context, thereby losing its value. Left with just first- and third-personal reasons the moral agent lacks strong reasons to act a certain way, leaving her confused about what would be the right thing to do.

Through altering reality, augmented reality also alters the context of an act. By changing the context, the first-, second, and third-personal reasons also change. Augmented reality not only allows a direct misrepresentation of reality, but also a misrepresentation of reality. If the context is biased, so will be the reasons, which derive content from the context. And although virtual reality could set a bad example for moral behaviour, augmented reality makes it possible to be the bad example. Augmented behaviour is not the behaviour of some virtual character, but the real behaviour of a person, in a semi-virtual world.

Without second-personal reasons, the moral agent relies on other moral reasons to act morally. If these reasons are tainted by a false presentation of reality, and people are left in a moral vertigo, than what would hold the moral agent from acting immorally? These concerns might sound rather serious, but what should we conclude? That augmented reality is pure evil? No, it can seriously benefit humanity in several ways. Enabling the blind man to see again; the nurse to finish a surgery when the doctor is incapable; finding our way through a city: augmented reality has many useful applications. Do we want to interfere with the development of augmented reality? No, for practical reasons. The concern I raised was born out of augmented reality being able to alter our reality. But altering reality is inherent to augmented reality. Altering reality is all augmented reality does. It would be rather inconsistent to first argue we should accept augmented reality to develop, but then argue that it should not alter our reality. No, the conclusion must be something else.

The main concern I raised in this thesis is the idea of augmented reality becoming our reality. As long as augmented reality exists as a tool, alongside reality, it has a lot of good to offer. But as soon as augmented reality becomes inseparable from our reality, when its addictive, hallucinogenic powers have taken control over our ability to separate the real world from a virtual, or augmented world, we allow ourselves to slip into a (moral) vertigo. Virtual objects would become as real to us as real objects are. It could take us closer to living in the matrix the movie warned us about, slowly sliding into a complete virtual world. What a world would that be?

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- *Figure B - Example of a QR-Code (page 12)*
If you could translate the code, it would read "http://www.wikipedia.com".
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The SAABTech AddVisor 150. Picture found on: <http://www.jvrb.org/articles/34/figure2.jpg>; last viewed 14th of June, 2011
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- *Figure E - The Future? AR contact-lens (page 14)*
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Azuma, Ronald T. "A Survey of Augmented Reality". In: *Teleoperators and Virtual Environments* 6, 4, 1997, page 11
- *Figure I - Showing the horizon can benefit pilots in night-time (page 42)*
Picture found on: http://farm5.static.flickr.com/4070/4336163331_173a9c72d5.jpg; last viewed on 14th of June, 2011

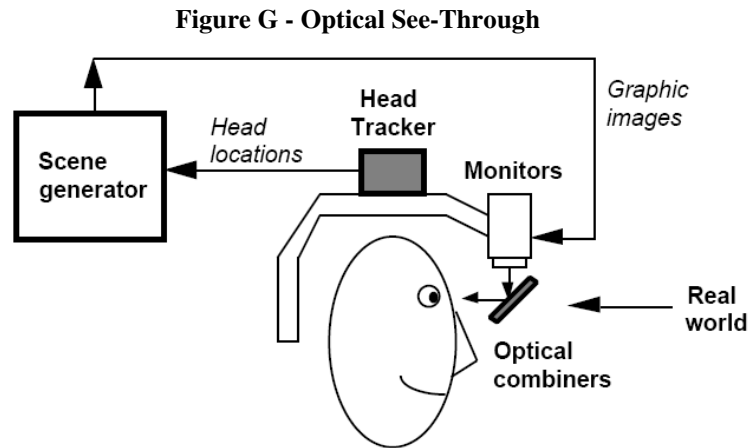
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Appendix

A – Optical and Video See-through: How it works

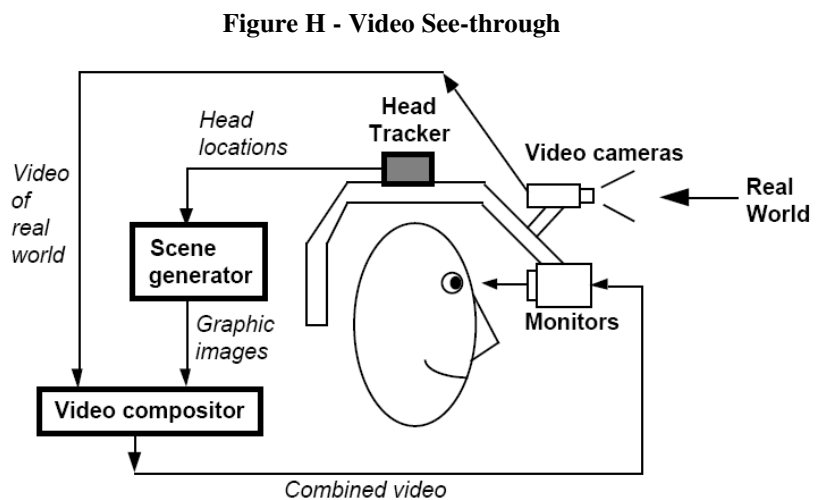
Optical See-through

One way of realizing some form of augmented reality is by simply adding a virtual layer to reality. You see the real world, and a computer only shows the virtual objects. A head-tracker, using several techniques such as accelerometers, gyro meters and GPS, determines the location of your head, and where you are looking at. A computer processes the data, and creates a digital layer, which is then displayed on a transparent screen (For a schematic overview, see Fig. G)



Video See-Through

Augmenting reality using video see-through techniques works rather similar, but instead of only adding a virtual layer to your sight, it adds reality as well. A head-tracker still determines your location and eyesight. What differs is that a camera is used to capture reality. A computer then combines the video-stream with virtual objects, and display it on a screen in front of your eyes. You thus not really see reality, just a recorded version. (For a schematic overview, see Fig. H)



Advantages and Disadvantages

Both techniques have advantages and disadvantages. Because optical techniques allows a user to see the real world, and adds virtual objects, there is a certain delay between the real world and the displaying of virtual objects. Especially when accuracy is required this can be problematic. Because video see-through techniques first capture reality through a camera, it can adjust the delay. Furthermore, letting the real world through creates problems with lighting. Because light of the real world shines through, virtual objects might have problems with the brightness. In short, video see-through techniques can blend virtual objects more accurate into the image of the real world.

The downside of using video see-through is that using a camera to capture reality, and a computer processing that extra stream of data, is more complex. Furthermore, a person is dependent on what is displayed on the monitor. "*If the power is cut off, the user is effectively blind.*"²⁶ But maybe more problematic is its delay. Although video see-through techniques remove the delay between the virtual object and the real world, it creates a delay between our eyes and our other senses. What we see would be just a fraction later than what we feel with our other senses, but it creates all kinds of discomfort: headaches, nausea. Optical see-through techniques allow you to see reality in real-time, bypassing this problem.

²⁶ Azuma, Ronald T. "A Survey of Augmented Reality". In: *Teleoperators and Virtual Environments* 6, 4, 1997, page 14

B – Applications of Augmented Reality

Military aircraft navigation & targeting

Probably the most known application of augmented reality is the use of head-mounted devices by helicopter-pilots (or does Figure I not ring any bells?). Through their helmet, pilots can see flight-data such as speed and altitude, but augmented reality can also display the location of enemies or targets, or navigate through unknown hostile territory. Another military application can be a way of aiming. "For example, the chin turret in a helicopter gunship can be slaved to the pilot's HMS, so the pilot can aim the chin turret simply by looking at the target."²⁷ Whether or not these applications already exist is presumably classified information. All we do know is that military R&D-departments are very interested in the technology.

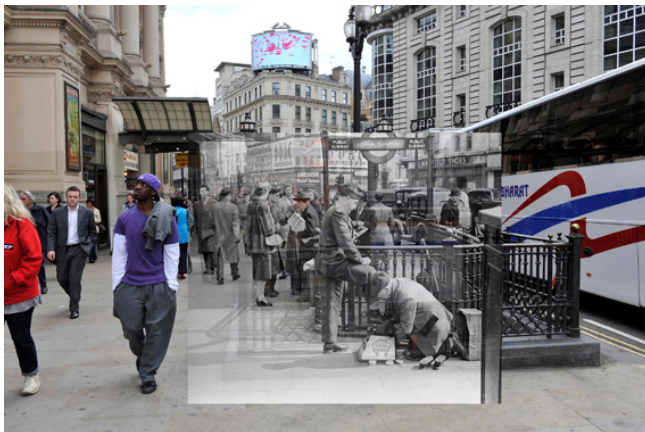
Figure I - Showing the horizon can benefit pilots in night-time



Entertainment

In the entertainment-industry only our imagination seems to limit the possibilities of augmented reality. I will roughly address three sections: games, performing arts, and activities. As for the latter, just think of possible amusement park attractions, such as scary houses. But also interactive infotainment in museums can be a possibility. In fact, several museums already are experimenting with all sorts of augmented reality to attract

Figure J - Museum of London iPhone Application



visitors. You could for instance download an iPhone App made for the Museum of London²⁸, which enables you to see how a specific London landmark looked like decades ago, while aiming your iPhone at that landmark (see Figure J).

As for the performing arts, we probably all have seen the movie 'Who Framed Roger Rabbit?'. For those who haven't: in this movie cartoon characters are mixed with real actors. With augmented reality, the movie could become a theatre-production.

²⁷ Id., page 9

²⁸ More information about the application can be found on:

<http://www.museumoflondon.org.uk/Resources/app/you-are-here-app/index.html>; 14th of June, 2011

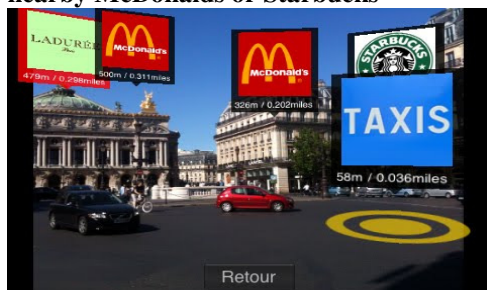
But probably the most exciting field in which augmented reality can be implemented is the games-industry. Games are all about immersing yourself into a virtual surrounding. Through games we can escape reality, at least for a moment. With augmented virtuality, such as Microsoft's Kinect, we can transform ourselves into virtual characters. With augmented reality we become the virtual character. We would be the star of a personalized video-game. In the introduction I already mentioned ARGames, one of the first games featuring augmented reality, but there are more. *"Some more [...] examples include ARhrrr!, an AR game that involves shooting down zombies from a helicopter view (handheld device) to save civilians; [...] and ARDefender, a tower defense AR game."*²⁹

Visualization & Annotation

Augmented reality can offer visual representations of how things could look like. Just like the application of the Museum of London, architects could use the same tool to envision how their plans would look like. *"An architect with a seethrough HMD might be able to look out a window and see how a proposed new skyscraper would change her view. If a database containing information about a building's structure was available, AR might give architects "X-ray vision" inside a building, showing where the pipes, electric lines, and structural supports are inside the walls."*³⁰

In a similar line, augmented reality can be used for commercial goals. If everyone is

Figure K - Augmenting the location of the nearby McDonalds or Starbucks



equipped with augmented reality equipment, buildings could display virtual billboards and special offers, attracting customers. This could also be useful for educational purposes. People would have access to the history of a certain landmark, or additional information on how to water a certain plant. Or it could enable a person to do a quick search of a library shelf: would it not be helpful if

augmented reality could show you the exact location of a specific book on a shelf?

Even more futuristic would be facial recognition software. As I said, it is quite challenging to develop such software, but I also mentioned Google to be working on it. It would create applications that could add information to a person's face. No longer will you forget to congratulate someone on her birthday, or forget her name. Personal information would be accessible in real-time. You could already scan the crowd in a bar for potential friends, based on their Facebook-photo's or whether they are single or not.

²⁹ Villagomez, Gianpierre. Augmented Reality. [Lecture notes] EECS 741: Computer Vision, University of Kansas, 2010

³⁰ Azuma, Ronald T. "A Survey of Augmented Reality". In: *Teleoperators and Virtual Environments* 6, 4, 1997, page 7

Maintenance, Manufacturing & Repairs

I worked for years in a major consumer-electronics company. Customers often asked me: how easy is it to install this device? Augmented reality could make it a lot easier. No longer would people have to read manuals, and try to translate the drawings in the manual to their actual situation, but just looking at the device would already tell which cable to plug in what socket. *"Instructions might be easier to understand if they were available, not as manuals with text and pictures, but rather as 3-D drawings superimposed upon the actual equipment, showing step-by-step the tasks that need to be done and how to do them."*³¹ BMW also acknowledges the usefulness of augmented reality as an instruction manual, and is working on its own application. *"Using augmented reality, the mechanic receives additional three-dimensional information on the engine he is repairing, for example, to help him in diagnosing and solving the fault. Apart from the real environment, he sees virtually animated components, the tools to be used and hears instruction on each of the working steps through headphones integrated inside the goggle."*³²

Medical

If it works on buildings and cars, it might also work on humans. *"Virtual instructions could remind a novice surgeon of the required steps, without the need to look away from a patient to consult a manual."*³³ But it would also offer doctors more specific knowledge of the patient. *"In effect, this would give a doctor "X-ray vision" inside a patient. Surgeons can detect some features with the naked eye that they cannot see in MRI or CT scans, and vice-versa. AR would give surgeons access to both types of data simultaneously."*³⁴ But there is more. An x-ray would not just be 2D, but 3D, and displayed on the patient herself. *"This might also guide precision tasks, such as displaying where to drill a hole into the skull for brain surgery or where to perform a needle biopsy of a tiny tumor."*³⁵

Figure L - X-Ray displayed directly on human ankle



³¹ Id., page 5

³² Information found on:

http://www.bmw.com/com/en/owners/service/augmented_reality_workshop_1.html; 14th of June, 2011

³³ Azuma, Ronald T. "A Survey of Augmented Reality". In: *Teleoperators and Virtual Environments* 6, 4, 1997, page 4

³⁴ Id., page 3

³⁵ Id., page 3